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A METHOD FOR EXPLORING SIMILARITIES AND VISUAL REFERENCES TO BRAND IN THE APPEARANCE OF MATURE MASS-MARKET PRODUCTS.

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Abstract

Product appearance and in particular its association with branding has been shown to play an increasingly important role in the commercial success of mature mass-market products. This paper presents a novel approach to analyse product appearance and explore similarities between products. The approach is applied to two contemporary industrial examples, smartphones and vehicles, and the outcome used to explore the strategic use of visual references to brand in product appearance. Results from the method's application validate the method in providing insights in terms of specific similarities in appearance. Further interpretation is then used to recommend possible design strategies with respect to the use of visual references to brand.

Keywords: aesthetics, design tools, evaluation, product design, styling

Appearance or styling has been shown to significantly influence consumer perception of products and subsequently their success in the market (Bloch, 1995, Crilly et al., 2004, Crilly et al., 2009, Person et al., 2007). This is particularly the case in relatively mature mass market products where there are a large number of competing products, with similar prices, functionality and performance (Van Breemen and Sudijono, 1999, Warell, 2004). Examples of this type of product where there is also particular emphasis placed on appearance include: consumer electronics such as mobile phones, computers, televisions; home appliances, such as vacuum cleaners, kettles, toasters; and transportation such as, motorcars, motorbikes, caravans and yachts.

For the aforementioned class of products, branding is a major factor in the design of appearance or styling (Bloch, 1995, Schmitt and Simonson, 1997, Warell et al., 2006). As such there is significant emphasis placed on branding and its management within the styling process (McCormack et al., 2004, Moulson and Sproles, 2000, Person et al., 2008, Person et al., 2007). Karjalainen (Karjalainen, 2003a, Karjalainen, 2003b, Karjalainen and Snelders, 2010) introduces the use of symbolic cues in design which are drawn on by designers to provide strategic visual references to brand for consumers. Examples of such features include the ‘waisted’ bottle shape adopted by Coca Cola or the ‘kidney grille’ seen on every BMW car (Karjalainen and Snelders, 2010, Beyer and McDermott, 2002, Ind and Watt, 2006). These features have been shown to come under particular scrutiny in the styling process and are becoming increasingly important aspects of registered designs and trade dress (BBC, 2012, Fanning, 2011, Warman, 2011). Companies may now protect particular aspects of features which they deem to be particularly symbolic in reference to their brand (McElhinny et al., 2011, W.I.P.O, 2012).

While the importance of product appearance and the strategic use of visual references to branding is demonstrated, there exists little support for designers in the evaluation of appearance and objective reasoning with respect to factors such as brand, trade dress, infringement of registered designs and novelty (Karjalainen, 2003a, Person et al., 2008, Person et al., 2007, Warell et al., 2006). Presently designers rely on previous experience and intuition in evaluating appearance. This in turn can lead to difficulty in communicating rationale behind styling decisions to other stakeholders in the design development process such as marketing and engineering departments (Warell et al., 2006).

It is this lack of supportive methods concerning the use of references to visual brand in mature mass market products that is the focus of this paper. In particular, the reported research investigates methods to assist designers in the objective evaluation of appearance. The paper begins by defining the precise aim of the reported research (section 1). Section 2 addresses the literature surrounding the topic of evaluation of appearance and similar studies. A method to assess product appearance and similarity is proposed in section 3, and its applications to smartphones and to vehicle fascias are presented in sections 4 and 5 respectively. Conclusions from the application of the

proposed method are drawn in section 6 which also reflects upon the limitation of the proposed method.

1. Aims and Objectives

The aim of the research reported in this paper is to create a method to facilitate objective evaluation of the degree of similarity in appearance for mature mass market products in terms of feature geometry. This in turn enables more informed evaluation and decision making during styling design and in particular the use of strategic visual references to brand.

The first step in achieving this aim is to create a set of analyses that may be applied to investigate different aspects of feature geometry. Following the creation of analyses, a method is proposed to evaluate the degree of similarity between features. To complete the method a framework is presented to facilitate the application of the analyses and subsequent degree of similarity calculations to products. The overall method is then applied to two product types, smartphones and vehicles, in order to test and validate the approach. Prior to the creation of the analyses and the overall method, literature detailing various approaches to measure appearance of objects is reviewed.

2. Background

Recent research relating to product brand and visual characteristics has centred on the subject of shape grammars (McCormack et al., 2004, Pugliese and Cagan, 2002). In these works, geometric rules are used to investigate visual references to brand in Harley Davidson motorcycles and Buick automobiles and generate new designs that maintain brand visual characteristics. The shape grammar (a set of geometric rules) was used to create designs in the form of 2d line representations in front and side views. Moving away from contemporary products, alternative approaches are used by Hawkins et al. (2001) to investigate historical artefacts. The topology of these artefacts is analysed in order to characterise the historic style in which they were designed. Cleveland (2010) investigates the spatial inter-relationships between text and graphics in order to characterise publishing layouts from a particular style. All of these studies, although relating to different areas of design, provide examples of the use of measures in various forms to analyse and subsequently characterise styles.

Relating to the process of design rather than its products, the FIORES projects discussed in Catalano et al and Cheutet et al. (Catalano et al., 2007, Cheutet et al., 2007) review the terminology and activities of automotive designers. The aim of the study was to characterise the geometric movements/transformations associated with activities and on terminology within the automotive styling process in order to assist designers by allowing them to adjust and edit the underlying geometry in CAD models with their own styling terminology. Thus the FIORES projects presented an

example of characterisation of geometric transformation in terms of designers' terminology.

A number of studies relating to human appearance, particularly facial properties, have been undertaken to further understand what constitutes typical and/or attractive properties (Farkas and Kolar, 1987, Jefferson, 2004, Schmidhuber, 1998, Terino and Flowers, 2000). These studies come from a number of different fields including aesthetic theory, classical art, and plastic and reconstructive surgery. In these studies, facial measurements and proportions of measurements are assessed to attempt to characterise ideal facial proportions of features.

All of the aforementioned literature presents different approaches to the characterisation of objects and their constituent features based on geometric measurements. Although not all of these studies address products, let alone visual references to brand, they all consider the geometry of features in terms of fundamental geometric entities: points, lines and spaces or areas. In the measurement of geometry, fundamental entities have properties of position relating to points, distance between points used to construct lines and space defined or bounded by lines (area). These fundamental geometric entities and their respective properties form the starting point for the creation of analyses that may be used to measure product appearance.

3.A method to assess product appearance and similarity

This section discusses the nature and context of measurement with respect to product features and products as whole. It then goes on to propose a number of analyses for quantitative measurement of product appearance and thus assessment of similarity.

The fundamental geometric entities and their properties, previously discussed in section 2, can be used to form a primary analysis of product appearance. In other words the relevant entities can provide a complete description of a feature's geometry. However this is done in isolation and, as discussed, there is a need to extend the analysis to consider the context of features within the overall product appearance or visual impression.

One approach for this is to extend the primary analysis to consider the basic measurements in comparison of features. In other words, by considering the same measurement in a number of features, it is possible to investigate the proportional relationships of geometry between features.

Furthermore, in measuring the constituent features of product appearance in isolation, it is possible to then measure the relative position of features. In effect, this is

measuring the space between features. It is contended that by extending the analysis to consider the geometry of a group of features, and the relative geometry between features, it is possible to analyse product appearance in terms of overall appearance rather than just features in isolation.

3.1. *Analyses of product appearance*

To achieve a more holistic assessment three analyses are proposed to evaluate individual features and their interrelationships within overall product appearance based on product geometry. These are: feature proportion analysis, feature orientation analysis and feature shape analysis. The result of applying all three analyses gives numerical data on a product's appearance that can then be used to derive what is referred to herein as the degree of similarity between products. Figure 1 introduces the three types of analysis using a generic product as an example. Sections 3.1.1 - 3.1.3 present the three analyses in detail and discuss the nature of the resulting data.

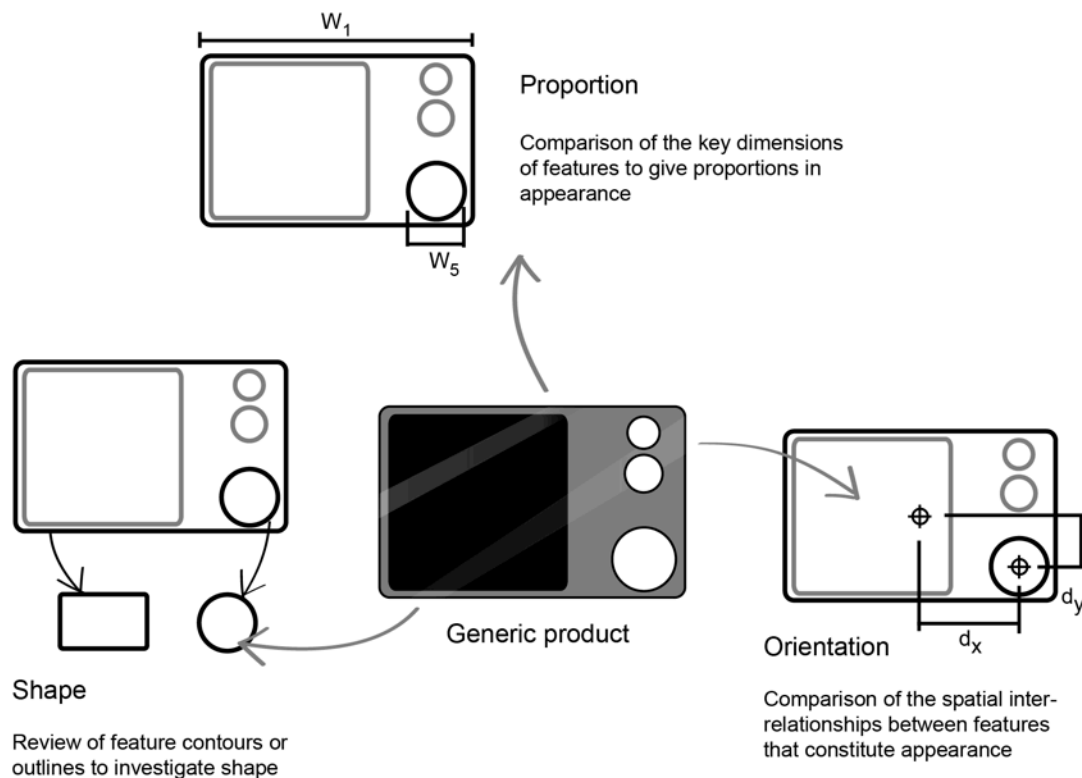


Figure 1 Summary of analyses used to evaluate appearance

3.1.1. Feature proportion analysis

In feature proportion analysis, area, perimeter, length and width of features are recorded as a proportion of the other features within the product. This analysis requires little further interpretation as proportions are immediately calculated and related to feature geometry. Patterns in a given proportion can then be reviewed and compared with other products by plotting values for specific proportions between

features across a range of products. The relationship between proportion analysis data and product features is illustrated in Figure 2. In this case the proportion between the widths of two features (W_1 and W_5) is calculated and plotted along with the same proportion from a range of other products.

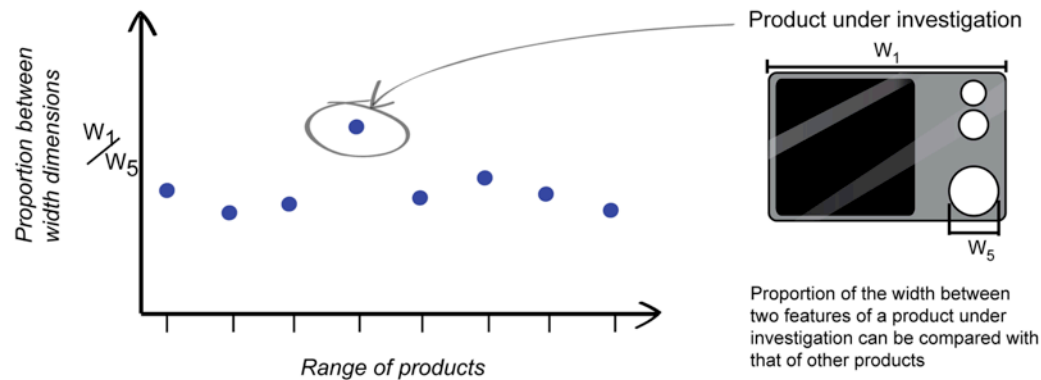


Figure 2 Illustrating feature proportion analysis

3.1.2. Feature orientation analysis

As with proportion analysis data, orientation analysis data is relatively self-evident and requires little interpretation. Orientation data includes coordinates for position of a feature's centre of area (henceforth referred to as centroid) and X and Y maxima and minima values. The axes against which these are plotted are defined by the centroid of a given feature. In the example included in Figure 3, the axes are based on the 'outline' feature. These axes may then be used for plotting all features of the product being analysed. The variation in position can be analysed across a range of products. The relationship between orientation analysis data and product features is illustrated in Figure 3. Here the location of the axes used to plot feature positions is shown with respect to the product image. In the right-hand part the position features' centroids, maxima and minima are shown plotted against the axes.

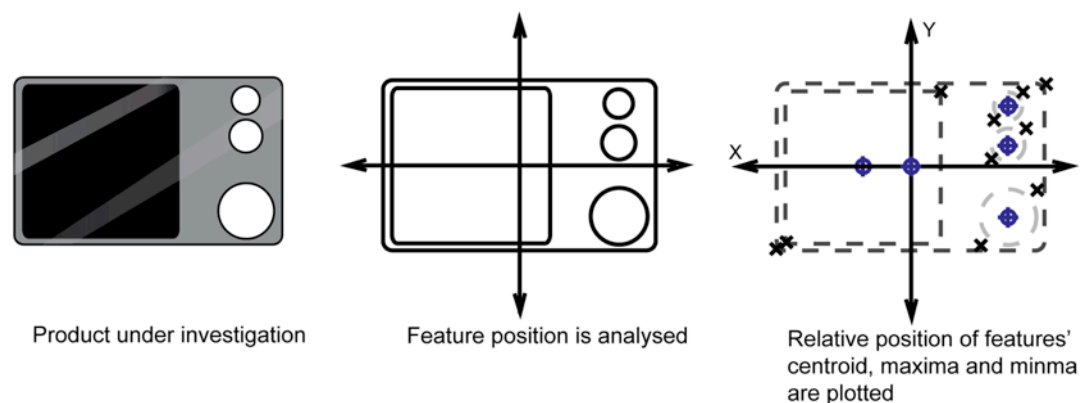


Figure 3 Illustrating orientation analysis

3.1.3. Feature shape analysis

Shape analysis is derived by calculating the radial length between a feature's centroid and a typical point on the feature's outline. This is repeated incrementally for a predefined number of points which are distributed evenly over the complete feature outline. The number of points is determined based on the complexity of the feature shape. From preliminary testing of the analysis, use of 90 points was shown to be appropriate for the complexity of shapes investigated in this research. The values for radial length can then be plotted for each incremental point. Unlike the proportion and orientation analyses, the shape analysis is less straightforward in terms of relating the feature shape investigated and the plotted shape analysis data. Figure 4 shows an example of a shape analysis applied to a feature from the generic product shown in previous figures. To further illustrate the analysis and its interpretation, Figure 5 shows examples of a shape analysis applied a number of shapes.

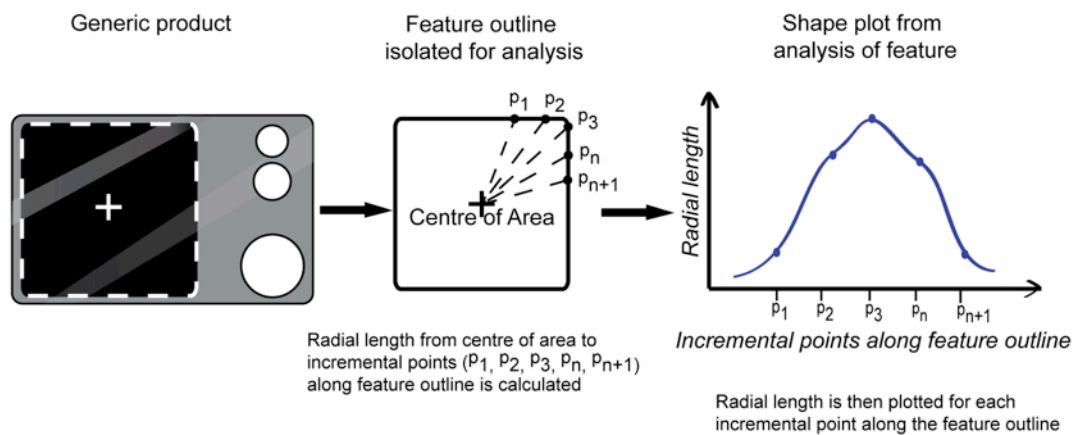


Figure 4 Illustrating shape analysis

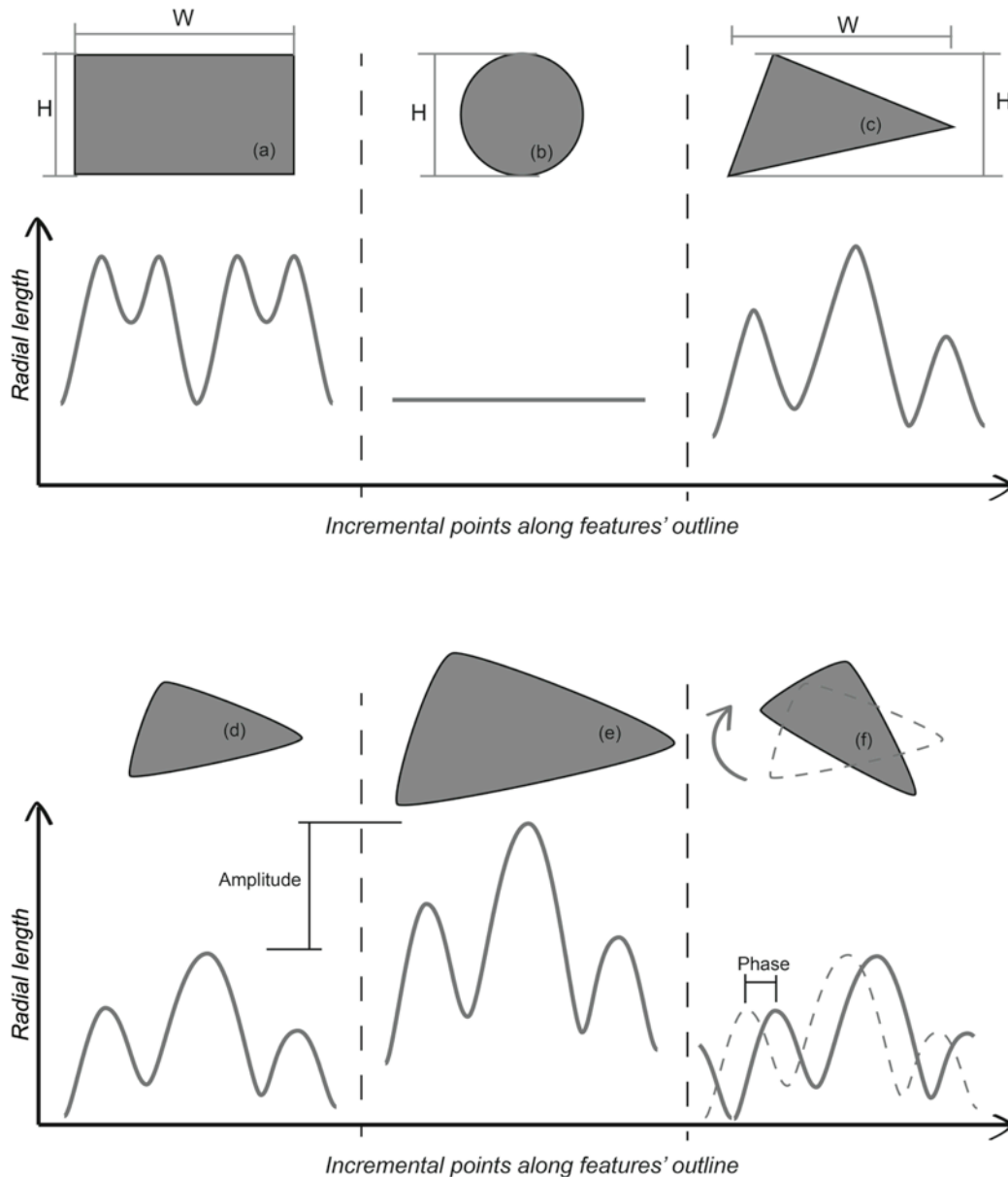


Figure 5 Examples of shape analysis data plotted for basic shapes

While the proportion analysis provides data relating to the relative basic dimensions of features and the orientation analysis to their relative position, the potential value in shape analysis is to identify similarities and differences between the outlined shape of features. This is demonstrated in Figure 5 shapes a, b, and c can be said to have the same height (H), and the rectangle (a) and the triangle (c) both have the same width (W), and lie on the same axis. The key (and obvious) difference between the features is their shape. The corresponding shape plots shown below their respective features demonstrate the manner in which it is possible to show differences in shape.

Shape analysis is also capable of highlighting similarity in the context of scale and rotation. Referring again to Figure 5, the same shape (d) is scaled (e) and rotated (f). The resulting shape plots demonstrate they way in which scale is shown in the shape

plot through difference in peak amplitude. Difference in shape plots as a result of rotation is shown in the difference in shape plot phase. While these differences can be highlighted, the similarity in the shape of outlines may still be observed in the path/profile of the shape plot. For the examples (d), (e), (f) given in Figure 5, this is seen in the number of peaks and relative amplitude and gradients. Should the designer wish, these contextual aspects such as scale and rotation can be removed for further comparison of shape. This is achieved by manually scaling and changing the phase of shape plots relative to a given shape.

A number of steps have been taken in order to ensure that shape plots for features of all shapes, sizes and rotations can be compared directly. Firstly the same number of points (90) are distributed equidistantly along the feature outline/profile for all features. This ensures that the length of the shape plots is the same for all features. Secondly incremental points are ordered such that the points can be considered equivalent for all types of feature shape. Simply put, incremental points all begin from the same or equivalent location, an example is where Y is a minimum and $X = 0$.

3.2. Assessing degree of similarity in appearance

This section builds upon the previously defined analyses in order to assess the degree of similarity between geometric aspects of product appearance. Similarity can be assessed in two forms. Firstly direct comparison between two features can be made. Secondly similarity can be assessed with respect to a range of features. This can be a range of different features within one product or, for the purpose of this study, a range of equivalent features from a number of different products. The details of the degree of similarity calculations are now discussed for each of the three types of analysis.

3.2.1. Degree of similarity in proportion analysis

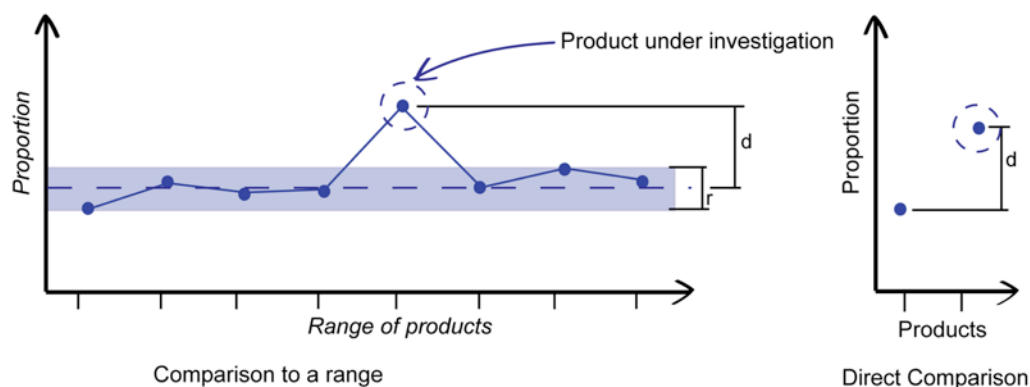


Figure 6 Illustration of degree of similarity calculation from proportion analysis

Direct comparisons of the degree of similarity can be assessed by calculating the difference (d) in any given proportion between the two products being compared.

For comparison with a group of products, degree of similarity is calculated as the difference (d) between the product under investigation and the mean value for proportion for the group of products (denoted by the dashed line in Figure 6).

The magnitude of the spread of values across the products investigated, termed the bounding range (r) of the products, can also be considered to provide further context to the assessment of the degree of similarity between a product and a group of products. This is done by dividing the difference (d) by the magnitude of the bounding range (r) for the product range investigated. This in effect gives a comparison of the variation of a given proportion/point from the mean of a group against the variation seen across the group. Hence d/r gives a value for the degree of similarity within the context of the variation across the range of products against which an individual product is to be assessed.

3.2.2. Degree of similarity in orientation analysis

The calculation of the degree of similarity in orientation analysis is similar to that used for proportion analysis. The major difference is that it is done in two axes as relative position is being considered. Hence in direct comparisons the difference in position is calculated in both X and Y directions as d_x and d_y . Similarly, with respect to a range of products, values for d_x and d_y are calculated as the differences in position to the respective X and Y range means (shown as the dotted lines through the bounding range in Figure 7). As with the degree of similarity calculations for proportion, the bounding range is considered. However, this is done in two dimensions (r_x and r_y). Hence for this analysis a value for degree of similarity is derived from d_x / r_x and d_y / r_y . The derivation of the range and values to calculate the degree of similarity are illustrated in Figure 7.

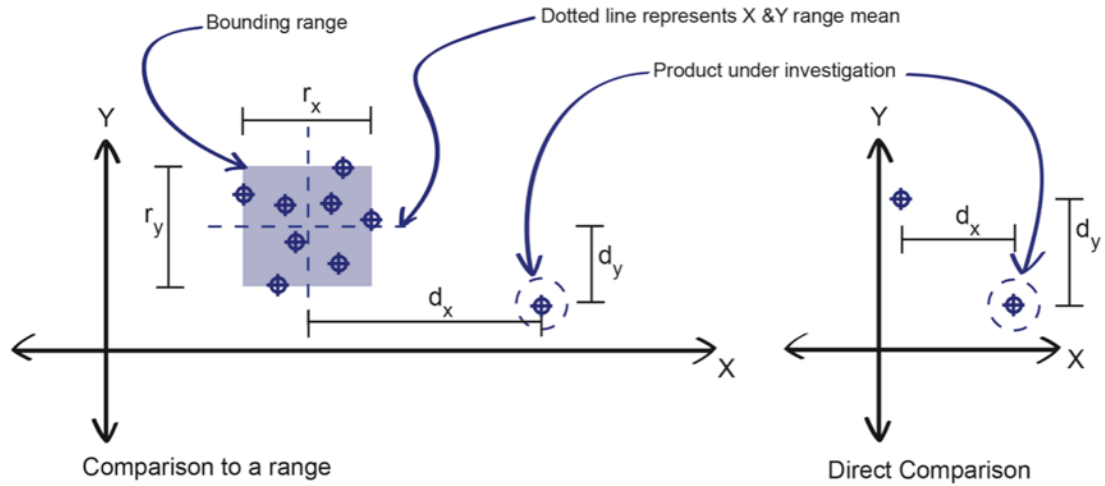


Figure 7 Illustration of degree of similarity calculation from orientation analysis

3.2.3. Degree of similarity in shape analysis

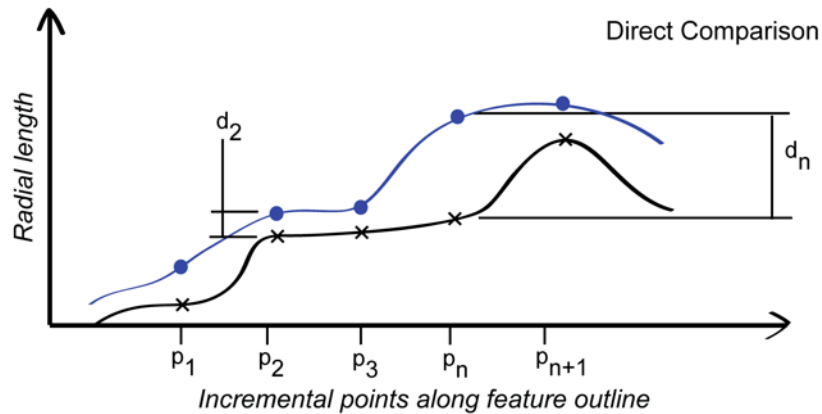


Figure 8 Illustration of degree of similarity calculation for direct comparisons from shape analysis

Degree of similarity calculations from shape analysis data also follow the same principle as those for proportion and orientation analysis. As discussed in 3.1.3, shape analysis plots the radial length from a given point on the feature outline to the feature's centre of area. Figure 8 illustrates the plot for this analysis with radial length on the Y axis and incremental points (labeled p_1, p_2, p_3, p_n and p_{n+1}) on the X axis. Thus, in assessment of the degree of similarity the difference between radial lengths (d_n) is calculated for each incremental point along a feature's outline. To obtain an overall measurement for the degree of similarity in the direct comparison of two features, the mean value for d over all points along the outline is calculated.

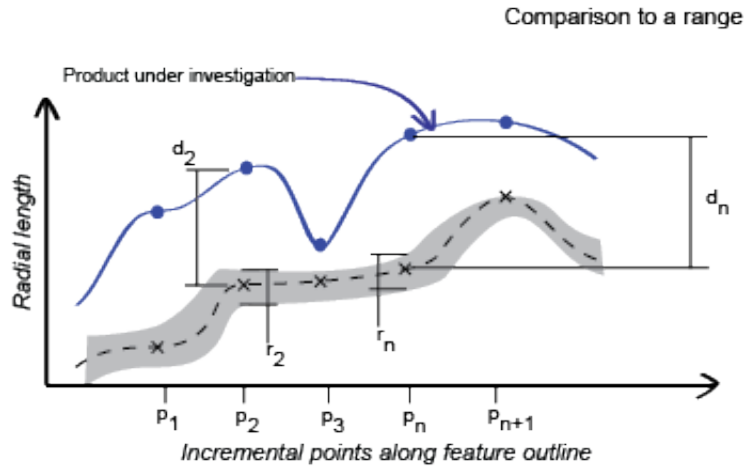


Figure 9 Illustration of degree of similarity calculation with respect to a range of products from shape analysis

As with other analyses, when calculating degree of similarity with respect to a group of products, a bounding range can be calculated using the mean value from the range of products. For shape analysis, the mean value across the range is calculated at each incremental point along the outline. The difference (d_n) for the product under investigation is calculated against the range mean for each incremental point (denoted by the dotted line in Figure 9). Similar to the other analyses, a value for degree of similarity with respect to a group is calculated for each incremental point d_n / r_n . This may then be averaged to give an overall value for degree of similarity for shape.

3.3. Assumptions associated with degree of similarity calculations

In order for the degree of similarity calculations to provide insightful data on similarity, a number of assumptions relating to the products examined must be made. Firstly a base or fundamental level of similarity is assumed.

3.3.1. Fundamental similarity

Fundamental similarity is defined as the presence of comparable features and observable similarity to the point where distinctiveness between products is based on nuances in feature shape, relative position and proportions between features. It is contended that these assumptions are reasonable because of a number of factors. Firstly the large number of products in competition with similar architecture, functionality and often parts, leads to a relatively high degree of similarity. With respect to products being designed, it is likely that numerous similar iterations on possible novel concepts are presented and subsequently evaluated in the design process. Furthermore, inherent in the concept of visual references to brand is

similarity or repetition in order that a feature can be familiar. Finally the proposed method only provides major contribution for designers in instances where there exists a relatively high degree of similarity across a group of products.

3.3.2. Size of bounding range

Within this assumption of base similarity there is some consideration as to the number of products included within the bounding range and the relationship with range size when calculating the degree of similarity. Figure 10 illustrates this consideration.

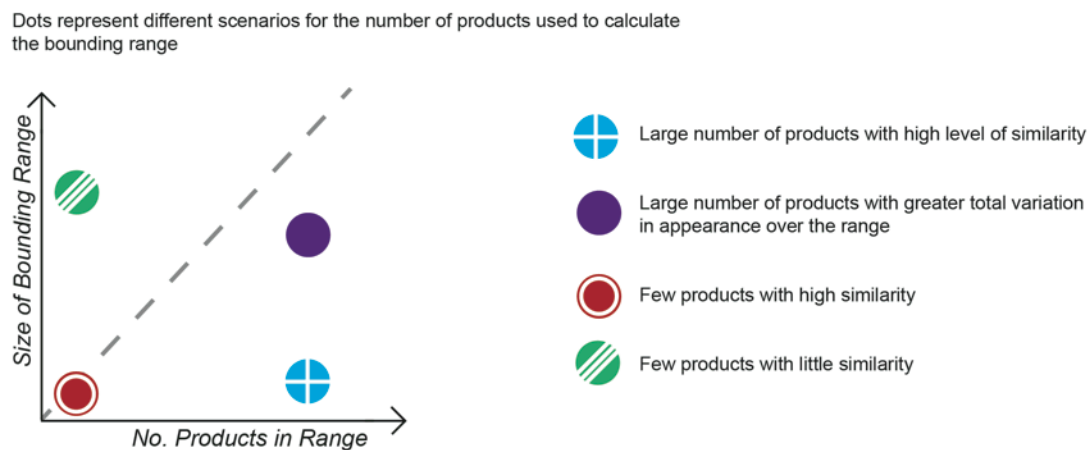


Figure 10 Illustrating the relationship between the size of bounding range and the number of products included

In the proposed calculation for the degree of similarity, the size of the bounding range is dependent on the similarity in product appearance among the range of products used to create it.

If there is little similarity in products' appearance under analysis, the likelihood is that the bounding range calculated will be overly large and consequently products compared with respect to this range may be incorrectly considered as similar. Although a large bounding range is too large for degree of similarity calculations, it can still be used to quantitatively show the level of variation in appearance. A further consideration to the size of the bounding range is the number of previous generations of products included. It is possible that a range of products may show strong similarity between adjacent generations. However when constructing a bounding range based on a large number of generations, the total variation in appearance and consequent bounding range may also be too large. Hence it is assumed that the fundamental level of similarity between products assessed is such that the calculated bounding ranges are small enough to provide reliable values for degree of similarity.

3.3.3. Inclusion of products in the definition of bounding ranges

When comparing feature geometry of a product to a group of products, there are two possible approaches for the definition of the product group. The first approach considers the product under comparison as being outside the group of products. The second approach considers the product under comparison as being included in the group of products.

Considering the use of the method to assess visual references to brand, it is assumed that the first approach is suitable when comparing a product to a product range produced by a competing manufacturer. It is also assumed that the second approach is suitable when comparing a product to other products made by the same manufacturer.

3.4. Overall method

Having proposed three types of analysis and the method to calculate degree of similarity for each, this section shows the method for their application. For the purpose of this study, feature geometry is derived by digitizing photographs of products. Photographs are used as it is not possible to access 3D surface modelling data for the products investigated in the case studies due to manufacturer confidentiality and, in the case of the second study, 3D models do not exist for all generations of products.

It is expected that, for the industrial application of the method, feature geometry is taken directly from CAD or digital surface models of products. The following sections summarise the method for digitizing product photographs to derive feature geometry and the software created to convert feature geometry into a form suitable for the analyses to be applied.

The process begins by using the visual decomposition process developed by Ranscombe et al. (Ranscombe et al., 2011) to define features. This technique traces feature outlines from product photographs. For the purpose of this study Adobe Creative Suite software was used to trace features using chains of curves.

Software was then created to input feature outlines and apply the analyses set out in 3.1 outputting data which could then be used to calculate the degree of similarity. This overall method is illustrated in Figure 11. It highlights the framework in which the three analyses are applied and subsequent calculations for the degree of similarity are made. It should be noted that prior to conducting case studies, the systematic error associated with digitization and decomposition was tested on a variety of images. A maximum margin of error of 3.25% was calculated, hence the proposed method was deemed to give suitably reliable results and thus be repeatable.

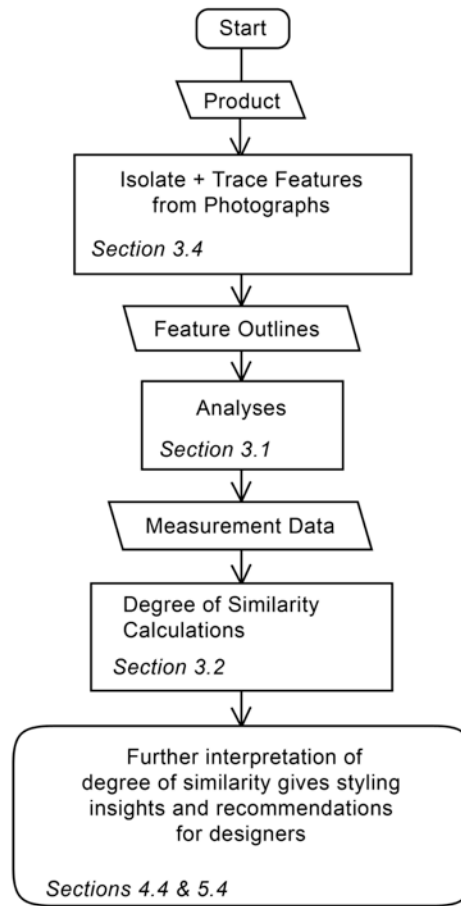


Figure 11 Overall method for applying analyses and assessing degree of similarity

4. Case study 1: Smartphones

This section reports a case study used to implement the analyses to assess product appearance and the method to apply them. It also explores the further use of the measures for degree of similarity to investigate strategic use of visual references to brand in a group of competing smartphones.

4.1. Products analysed

Six competing smartphones are assessed in this case study. They are the Apple iPhone 4, iPhone 3G and original iPhone 2G, The Samsung Galaxy S, Galaxy S2 and the HTC Incredible S. Photographs of the smartphones that the method is applied to are compiled in Figure 12.



Figure 12 Photographs of smartphones used as the subject of the case study

One of the motivations for applying the proposed method to this range of products was that some are the subject of litigation concerning similarities in appearance. In April 2011 Apple alleged Samsung had “slavishly copied” their smartphones and filed a lawsuit against Samsung on the grounds of infringing upon Apple’s intellectual property (Warman, 2011). These allegations include claims that Samsung’s products infringe on the grounds of trade dress. One aspect included under the umbrella of trade dress is product appearance or form (McElhinny et al., 2011). This aspect of the trade dress litigation is of particular interest to the research and the proposed method as this case highlights the importance of product appearance and branding. It also provides an exemplar case in which the proposed method can provide objective assessment of the product’s appearance.

4.2. Features analysed

The visual decomposition technique discussed (section 3.2) is applied to front elevations of each phone. The front view is used as this is the view most heavily referenced in the litigation (McElhinny et al., 2011) and by inspection can be seen to be most similar. The features isolated using the visual decomposition approach are illustrated in Figure 13 using the Apple iPhone 4 as an example.

The boundaries of features are defined as the physical edge of a particular feature or part. For the outline feature the boundary is defined by the horizon line. As high-resolution photographs are used the edges can be identified easily by eye when the photograph is zoomed in/blown up.

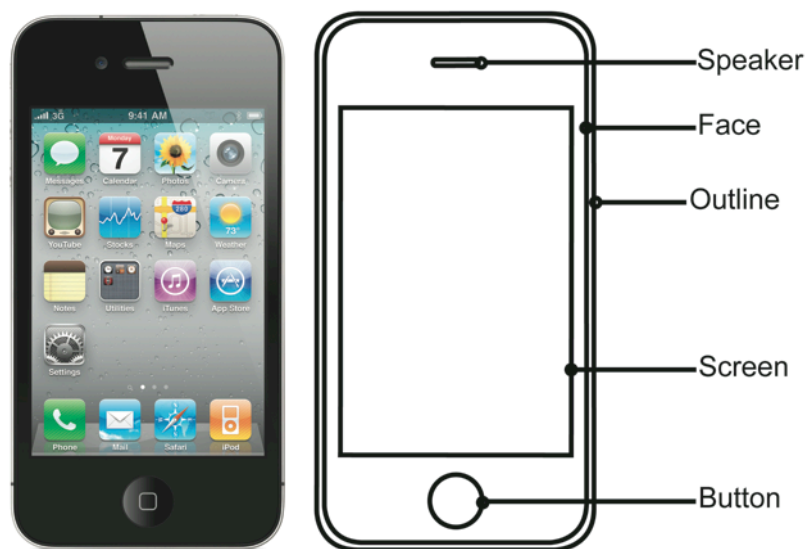


Figure 13 Demonstration of features isolated in visual decomposition using the Apple iPhone 4 as an example

4.3. Calculating degree of similarity for smartphones

To give further insights into the claims made by Apple relating to trade dress infringement, the degree of similarity calculations used for this case study compare features of the Samsung Galaxay S , S2 and HTC incredible S with the Apple iPhones as a group. Thus the bounding range (r) in Figure 5 - Figure 9 is derived from the iPhone range. The difference (d) in Figure 5 - Figure 9 of the Samsung and HTC phones is then compared against the Apple bounding range. If $d/r \leq 1$ for a feature or point, these may be considered to be within the bounding range of the Apple smartphones. Said differently if $d/r \leq 1$ the difference from the mean of a point or

feature is within the variation seen within Apple iPhone range. Thus, in this condition, it can be said that points/features are similar to the Apple iPhone range.

4.4. Results and discussion

Visual inspection of the smartphones assessed suggests they are relatively similar. Hence, for this case study the significant contribution in applying the method is derived from the objective evaluation and measurement of degree of similarity.

Using the method for each analysis (sections 3.2.1 - 3.2.3) and their further interpretation set out in section 4.3, the following objective evaluations are made for the smartphones assessed.

From the shape analysis, degree of similarity calculations comparing these shape plots show, most notably, that the Samsung Galaxy S and HTC have 71% and 94% of points respectively within the Apple range for the shape feature. The screen and outline features are less similar with between 24% and 9% of points lying within the Apple range.

A more substantial difference in shape was observed in the button features reflecting the more distinctly shaped button used by Apple and Samsung, circular and rounded square respectively. It should be noted that there is no equivalent button feature on the HTC model.

With respect to the orientation analysis, it is noted that designs are symmetrical about the (vertical) Y-axis. Additionally symmetry or balance in placement of speaker and button features is observed in the similar distances of the respective centroids from the origin. Consequently degree of similarity calculations show that for the five features, 6, 8 and 7 of the ten position coordinates (five X and five Y) for Samsung S, S2 and HTC phones respectively, were within the Apple bounding range. Position of maxima and minima further show the symmetrical nature across all of the smartphones and the similar shape characteristics highlighted in the shape analysis.

Degree of similarity calculations show that, of the total (16) proportions compared, 6/16 of the Samsung Galaxy S features are within the Apple bounding range and 5/16 features of the Samsung Galaxy S2 are within the Apple bounding range. Of particular note is that the Face and Screen features expressed as a proportion of the outline consistently have similar relative proportions across all dimensions while button and speaker feature proportions differ more. The HTC is not within range in any of the instances.

With respect to visual references to brand and the litigation surrounding the smartphones, the results provide a number of insights. In the most direct sense the results give an objective evaluation of the similarities and the degree to which features are similar. Additionally the results can be used to calculate a bounding range for the

Apple smartphones. In calculating this range, results also give an indication of the consistency of the Apple products thus informing what may be argued to constitute visual references to brand and the possible strength of these references. The results are not intended to prove either way whether there has been an infringement of intellectual property. The results do however provide a number of objective insights that could be valuable.

With respect to the significance of this analysis method for designers, the results provide a number of recommendations or strategies. The measures for similarity of features may be used by designers in a number of ways. Firstly the similarities highlighted in the results can be used as guidelines for areas of the design a designer for Apple may choose in order to perpetuate familiarity. Conversely designers from competing brands may use results to guide areas of design in which to further or better differentiate from the Apple brand aesthetic. Finally the results provide an objective datum that can be used if designers wish to use a similar aesthetic while ensuring that no infringement is made.

5. Case study 2: Vehicle fascias

This section reports the second application of the proposed method to assess product appearance. This cases study concerns the analysis and calculation of the degree of similarity of current and previous models of BMW vehicles. The rationale for applying the method to this type of product (vehicles) is now discussed followed by further details of the implementation.

5.1. Products analysed

Vehicles as a product type have been selected as the subject of the second case study to demonstrate the wider generality of the proposed method. The main differences of vehicles as a case compared to smartphones comes in two forms. First, the products differ greatly from smartphones in terms of their physical scale, use and perceptions, and the types of forms embodied in their design. The second difference concerns their context with respect to the use of the proposed method. This case study considers a range of products made by a single manufacturer. The products are reviewed from the perspective of investigating consistencies and evolutionary trends in appearance. In contrast, the previous case study assessed only key similarities and differences from the perspective of competition.

Hence, this study uses vehicles from the current BMW range (at the time of conducting this research) as well as exploring a number of previous 3-Series and 7-Series designs.

5.2. Features analysed

The proposed method is applied to 'graphic' features as these have been shown to significantly influence recognition of brand (Karjalainen and Warell, 2005, Ranscombe et al., 2011). Thus they can be said to incorporate visual references to brand. The graphics features assessed are: the badge, grille, headlight, lower side air intake and fog-light cluster, and central air intake. As with case study 1 features are isolated for investigation using the visual decomposition technique (Section 5.3). The features isolated using the visual decomposition approach are illustrated in Figure 14 using the current BMW 3 series as an example.

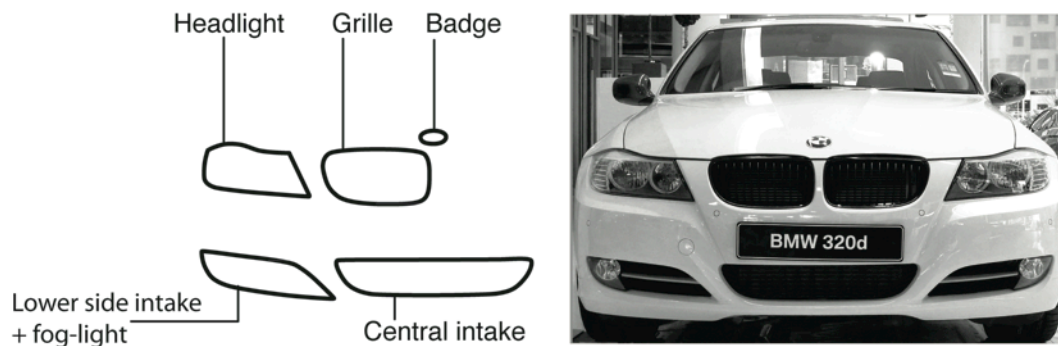


Figure 14 Demonstration of features isolated in visual decomposition using the BMW 3-Series as an example

It is noted that the BMWs use a split 'kidney-grille'. This is assumed to be symmetrical and thus only one side is investigated. Similarly the headlights and lower side air intake and fog light cluster are assumed symmetrical about the vertical centre and thus only one side is considered.

Boundaries of features are defined as in case study 1 (section 4.2). There are some instances where boundaries require some subjective judgment as there is no obvious change in material or part. This, although not ideal, is only a consequence of the requirement to use photographs and subjectivity can be removed if digital models are used as the basis of investigation.

5.3. Calculating degree of similarity

The calculations used in this case study are largely similar to those used in case study 1, outlined in section 4.3. The calculations change slightly in that the differences (d) are explored in order to investigate evolutionary trends and used to calculate variance from the mean rather than for comparison to a range (r) to explore consistency.

5.4. Results and discussion

Results from this case study highlight the grille and headlight features as exhibiting greatest consistencies and trends in both current and previous ranges. The shape analyses show that in the current range there is relatively high consistency in these shapes. In terms of degree of similarity calculations grille and headlamp have a coefficient of variance of 0.234 and 0.173, approximately half the corresponding values for the other features. It also shows the particular areas in the features' contour/outline where the designs differ the most, that is where they are most inconsistent. These findings are illustrated in Figure 15.

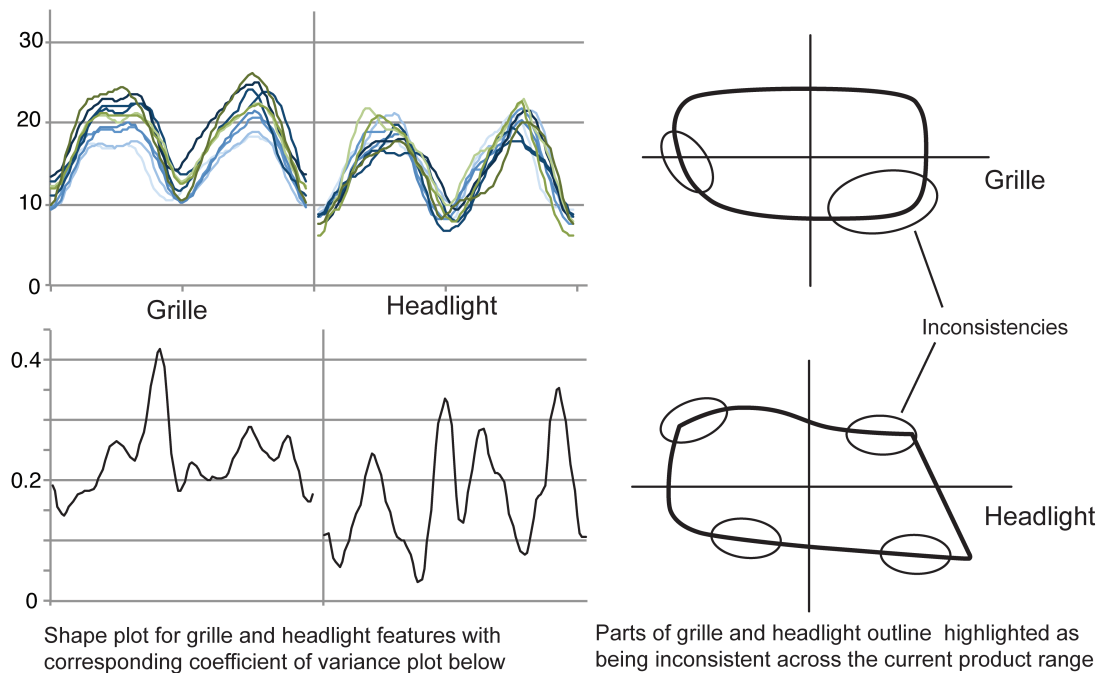


Figure 15 Shape analysis results showing inconsistencies in grille and headlight feature contours

In review of the shape of the grille across previous products it can be seen that the grille grows wider (in the X axis). This finding is echoed in the results from the proportion and orientation analysis.

Degree of similarity calculations from the orientation analysis highlight major consistencies in the current range in the X component of: the headlight centroid (variance 0.178), headlight minima (variance 0.105) and grille maxima (variance 0.076). Results from the orientation analysis of the previous models show far less consistency. Values for variance are two orders of magnitude greater than those highlighted above with the exception of the X component of the grille maxima whose variance is 0.338.

From the orientation analysis of previous models, it possible to observe evolutionary trends in the increasing distance of the grille centroid from the badge in the evolution of models, reflecting the observation in the shape analysis of the grille becoming wider. The same is also true for the headlight centroid. This pattern is repeated in the maxima and minima.

Degree of similarity calculations from proportion analysis show consistency in grille and headlight relationship with variance of approximately 0.02 for all dimensions assessed. Proportion analysis of the previous models highlights evolutionary change in area, perimeter, and width echoing the growth of the grille in width. Conversely the height proportion also remains consistent over previous models, with a variance of 0.008. This evolution of the relationship between the grille and headlight is illustrated in Figure 16.

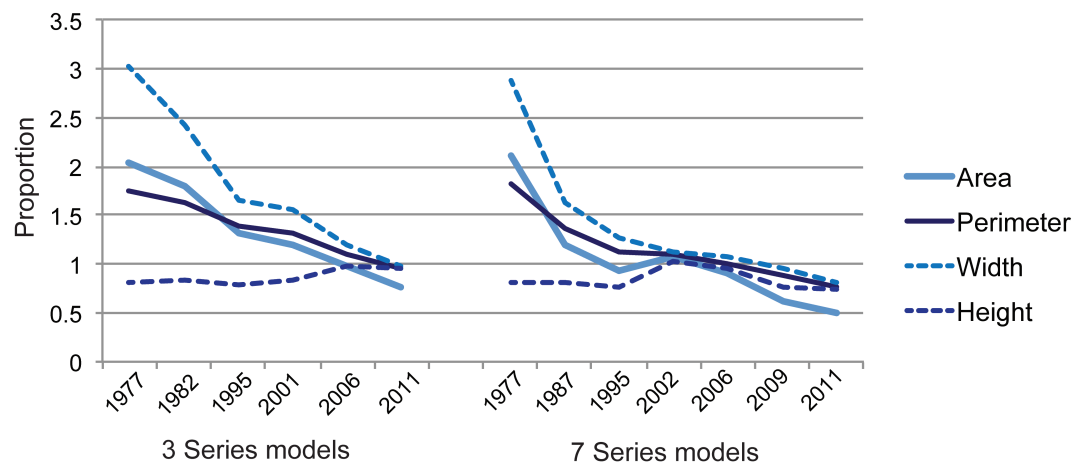


Figure 16 Evolution of proportions between Grille and Headlight features over previous generations of vehicles

It is noted that vehicle widths also increase with subsequent generations. However, the total factor by which they increase is 1.12 for 3 series and 1.05 for 7 series respectively substantially less than the total factor for the increase in grille width (3.58 and 1.60 for 3 and 7 series respectively).

The findings relating to the consistency in grille and headlight features can be combined to provide a framework for designers that outlines the aspects of appearance that can be classed as strategic visual references to the BMW brand. The orientation and proportion analyses provide guidelines for the spatial interrelationships and overall dimensions while the shape analysis provides some guidelines for the contour.

From assessment of previous products the results show a trend for the widening of the grille feature. The evolution may in turn be used as a trajectory for the feature's future form and evolution of visual references to brand. This can be

followed to promote familiarity in designs or strategically altered to create greater impact for designs. Strategic change may also be applied to features that are found to be consistent over ranges to create distinctive appearance within the brand portfolio.

The lack of consistency and trends in lower side intake and fog-light cluster and the central intake also provide some recommendations for designers. The lack of trends highlights these features as a possible area for development of greater consistency among designs. Conversely these features may provide greater freedom and can change styling frequently to differentiate older models while relying on the grille and headlight features to carry visual references to brand.

6. Limitations and proposals for improvement

As mentioned previously (section 3.4) product data was generated from photographs. The use of photographs as the base material gives rise to a number of limitations.

The first limitation induced by the use of photographs is that accuracy in tracing features is dependent on image resolution. Image detail also has an effect on the ability to define what constitutes the boundary of features. This becomes particularly difficult when attempting to apply consistent judgement across different types of product. Finally there is an inherent limitation in that resulting geometry is 2 dimensional and hence an abstraction from reality. Use of 2 dimensional representations has however been shown to sufficiently communicate product type (Biederman, 1987, Biederman and Ju, 1988) and visual branding (McCormack et al., 2004, Pugliese and Cagan, 2002, Ranscombe et al., 2011).

While these limitations are acknowledged, it is contended that they do not majorly impact results in either case study presented. This is primarily due to the types of feature investigated in both studies and that they may be defined by physical edges or parts.

In terms of improvement, these limitations could be removed by the use of 3D surface model data for analysis. As stated in section 3.4 it is expected that such data would be available and hence used when applying the method industrially. Use of such data removes limitations in that there is no longer a need to digitize photographs. In other words the real/actual geometry is readily available. Thus there are no longer limitations related to the complexity to which features may be reviewed or any abstraction of geometry. Readily available geometry also means that generic rules can be generated to provide a geometric definition of feature boundaries. Subsequently the same definitions can be applied less

subjectively and more repeatably for a wide range of feature types and also product types. It is however acknowledged that, while the creation of geometric rules to define features can reduce subjectivity, there still remains a degree of subjectivity in the derivation of these generic rules.

It is contended that the analyses proposed in this paper can be easily extended to consider three dimensions. This would be achieved by considering a third dimension in proportion analysis, thus investigating volume and depth. For orientation analysis, depth (the Z axis) is easily added. In shape analysis, a 'cloud' of incremental points on a surface can be assessed against a feature's centre of volume. Subsequent shape plots can then be represented and compared as surface plots.

7. Conclusions

This paper reports a method to facilitate objective evaluation of the degree of similarity in the appearance of products and thus inform evaluation and decision making with respect to strategic visual references to brand. Within this study three analyses have been proposed in order to generate a quantitative assessment of similarity. These include: a proportion analysis to evaluate proportions of fundamental geometry between features; an orientation analysis to investigate the relative positions of features; and a shape analysis to consider the differences in the form of edges and corners/transitions.

Applying the method in two case studies demonstrates the utility of the method to assist designers in the evaluation of appearance during the design process in a number of ways. Firstly the case studies show the way in which application of the method provides assessment of similarity through quantitative measures for the degree of similarity. This in itself is of value in that it can show similarity objectively across multiple products in a way that is not possible by simple visual inspection.

Furthermore the case studies show that by using ranges of products with different contexts, further meaning that can be derived from the measures for the degree of similarity. Observation of key consistencies and differences in appearance can then be used to inform strategic references to brand and provide designers with insights into possible design strategies. The first case study showed the use of the method to explore possible design infringement and how designers may be able to create designs that are more distinct or maintain similarity while avoiding litigation.

The second case study showed the use of the degree of similarity to explore features and create design guidelines for what can be said to constitute visual references to brand. Assessment of previous products showed an evolution of influential features which further informs their strategic use in future designs.

Thus the case studies show some of the possible uses of the method to designers. These in turn highlight the ways in which the method assists in the design process. Primarily the objectivity of the results facilitates quantifiable reasoning on product appearance that is easily communicated both within design teams but also to associated teams such as marketing and engineering. Additionally the effect of design changes, no matter how minor, can be quantified avoiding misinterpretation. This improved communication and knowledge in turn provides designers with a better rationale and the ability to demonstrate said rationale during evaluation. All of these can facilitate quicker iterations during the process of design due to reduced time spent in evaluation. Finally it is also contended that improved understanding and reasoning can give designers greater freedom as they are afforded a better platform on which to reason about designs.

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